65%

Phys 131
Fall 2016

Fundamental Mechanics: Class Exam I

16 September 2016

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Instructions

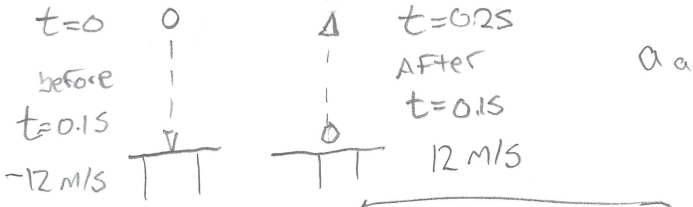
- There are 8 questions on 5 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

$$g = 9.80\,\text{m/s}^2$$

Question 1

A ball falls toward a table and bounces back. At an instant 0.10 s *before* it hits the table it moves down with speed 12 m/s and at an instant 0.10 s *after* it hits the table it moves up with speed 8.0 m/s. Determine the average acceleration of the ball between the two instants.



$a_{avg} = \frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{\Delta t}$ $\Delta t = 0.2s$

$V_f = 12$ m/s $V_i = -12$ m/s

$\frac{\Delta V}{\Delta t} = \frac{12\text{ m/s} - (-12\text{ m/s})}{0.2s}$ 8m/s (-1)

$\frac{\Delta V}{\Delta t} = \frac{20\text{ m/s}}{0.2s} = 100\text{ m/s}^2$

$A_{avg} = 120\text{ m/s}^2$

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Question 2

Vector $\vec{\mathbf{A}}$ has magnitude 2.0 m and vector $\vec{\mathbf{B}}$ has magnitude 3.0 m. These could be oriented in any directions. Which of the following (choose one) is true regarding the possible magnitude of $\vec{\mathbf{C}} = \vec{\mathbf{A}} + \vec{\mathbf{B}}$?

i) The smallest possible magnitude is $C = 0.0$ m.
ii) The smallest possible magnitude is $C = 1.0$ m.
iii) The smallest possible magnitude is $C = 2.0$ m.
iv) The smallest possible magnitude is $C = 5.0$ m.

$\vec{C} = \vec{A} + \vec{B}$

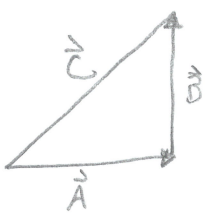
$\vec{C} = 2.0\text{m} + 3.0\text{m}$

$\vec{C} = 5.0\text{m}$

3.0m $\vec{B}$

2.0m $\vec{A}$

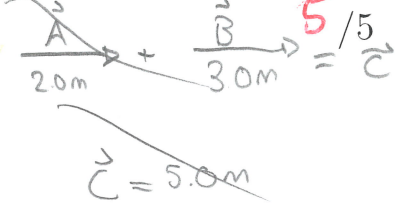
$\vec{C} = 1.0\text{m}$



$C = \sqrt{|A|^2 + |B|^2}$

$C = \sqrt{4 + 9}$

$C = \sqrt{13}$



5/5

Negative velocity corresponds to walking left or down. Horizontal lines on velocity vs. time graphs indicate no velocity therefore no change in position no, they don't.

Question 3

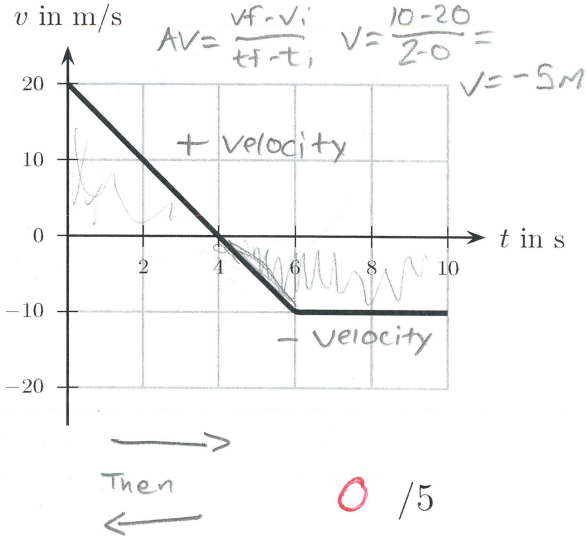
The velocity vs. time graph for an ant that walks along a straight wire is illustrated. At $t = 0$ s, the ant is located at the $x = 0$ m mark. Which of the following (choose one) is true *during the interval from* 0 *s to* 10 *s?*

i) The ant always moves left during this interval.

ii) The ant always moves right during this interval.

iii) The ant moves right and then left but *never* returns to the $x = 0$ m mark during this interval.

iv) The ant moves right and then left but *does* return to the $x = 0$ m mark at some point during this interval.



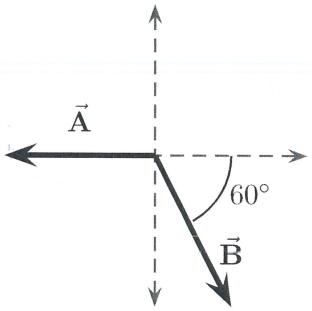
$\Delta v = \frac{v_f - v_i}{t_f - t_i}$ $v = \frac{10-20}{2-0} =$ $v = -5$ m/s

Then →

0 /5

Question 4

Two displacement vectors are illustrated. The magnitude of $\vec{\mathbf{A}}$ is 100 m and that of $\vec{\mathbf{B}}$ is 150 m. Let $\vec{\mathbf{C}} = \vec{\mathbf{A}} - \vec{\mathbf{B}}$. Express $\vec{\mathbf{C}}$ in terms of standard unit vectors and determine the magnitude of $\vec{\mathbf{C}}$.



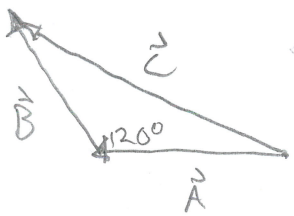
$|A| = 100$ m

$|B| = 150$ m

$\vec{C} = \vec{A} - \vec{B}$ (+2)

$\vec{A} = -100\hat{i}$

$\vec{B} = -75\hat{i} + 129.9\hat{j}$



$\vec{A} =$ ← $\vec{A}$

$\vec{B} =$ ↘ $\vec{B}$

$-\vec{B} =$ ↖ $\vec{B}$

$\vec{C} = \vec{A} - \vec{B}$

$\vec{C} = -100\hat{i} - \vec{A}$

$-75\hat{i} + 129.9\hat{j} - \vec{B}$

$\vec{C} = -175\hat{i} + 129.9\hat{j}$

$\vec{B}$

X-comp

$h\cos\theta$

$h = 150$ m $\theta = 120°$

$150\cos 120°$

$X = -75\hat{i}$

Y-comp

$h\sin\theta$

$h = 150$ $\theta = 120°$

$y = 129.9\hat{j}$

8 /10

Question 5

A car passes a road marker with speed 40 m/s and at this point the brakes are applied, resulting in a constant acceleration of $-6.0\,\mathrm{m/s^2}$ for the next 5.0 s. After this the brakes are instantly released and the car travels at constant speed. Determine the total distance that the car has traveled at an instant 8.0 s after it passed the marker.

$t_0 = 0.0\,s$ $t_1 = 8.0\,s$

$x_0 = 0m$ $x_1 = ?$

$y_0 = 0m$ $y_1 = 0m$

$v_{0x} = 40.m/s$ $v_{1x} = -8m/s$

$v_{0y} = 0\,m/s$ $v_{1y} = 0m/s$

$a_x = -6.0\,m/s^2$ $a_x =$

$a_y = -9.8\,m/s^2$ $a_y = -9.8\,m/s^2$

Only accelerates from 0 → 5s

Find final velocity $v_1x = v_{0x} - a_x\Delta t$

$v_1x = 40\,m/s - 6.0m/s^2(5.0s)$

$v_1x = 40\,m/s - 48\,m/s$

$v_1x = -8\,m/s$ (+1)

gives v at 5.0s

Total Distance $x_1 = x_0 + v_{0x}\Delta t + \frac{1}{2}a_x(\Delta t)^2$ (+2)

$x_1 = 0m + 40m/s(5s) - 3.0m/s^2(5s)^2$

$x_1 = 320\,m - 192\,m$ (+1)

$x_1 = 122\,m$ (+3)

122 m past marker

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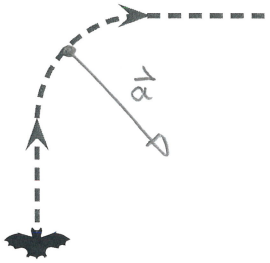
Question 6

A bat flies horizontally at a *constant speed*. For a while the bat flies straight south. It then curves gently and later flies straight east. The bat's trajectory is illustrated looking up from the ground. Describe when, if ever, its acceleration is zero and when, if ever, it is not zero. Explain your answer.



The acceleration is zero when the bat is flying strait South or east. The acceleration is not zero when it is changing from strait south to East because its direction is changing ∴ its accelecation is changing.

why does accel connect to direction?

(-2)

$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$

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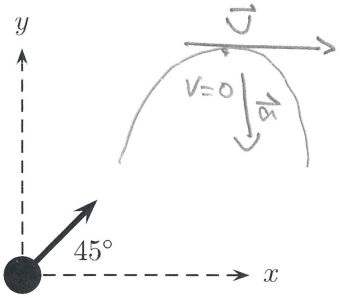
Question 7

A ball is fired into the air at an angle of 45°. Which of the following (choose one only) best represents the velocity and acceleration at the *moment at which the ball reaches its highest point*? Ignore air resistance.



i) both are 0 and so directions are irrelevant,

ii) $\vec{\mathbf{v}}$ is $\rightarrow$ and $\vec{\mathbf{a}}$ is $\rightarrow$,

iii) $\vec{\mathbf{v}}$ is $\rightarrow$ and $\vec{\mathbf{a}}$ is $\downarrow$,

iv) $\vec{\mathbf{v}}$ is $\nearrow$ and $\vec{\mathbf{a}}$ is $\downarrow$,

v) $\vec{\mathbf{v}}$ is 0 and $\vec{\mathbf{a}}$ is $\rightarrow$,

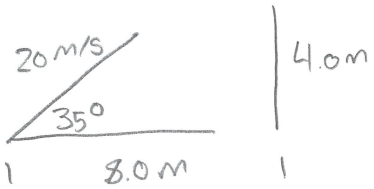
vi) $\vec{\mathbf{v}}$ is $\rightarrow$ and $\vec{\mathbf{a}}$ is 0.

The ball is at its highest point when $\vec{v}=0$. If velocity is not changing or if velocity is zero, then acceleration is zero.

0/5

Question 8

A ball is fired from the ground, leaving with speed 20 m/s at an angle of 35° toward a vertical wall, which is 4.0 m high and is located 8.0 m horizontally from where the ball is fired. Determine whether the ball passes above the wall or not and the vertical height by which it clears or misses the wall. Ignore air resistance.



X-component

$h\cos\theta$

$h = 20\ m/s \quad \theta = 35^\circ$

$20\cos 35$

16.4 m/s ✓

Y-component

$h\sin\theta$

$h = 20\ m/s \quad \theta = 35^\circ$

$20\sin 35$ ✓

11.5 m/s

The ball clears the wall by 1.52 m. That is because

$\Delta y = (5.52\text{m})$

$5.52\text{m} - 4.0\text{m}$

Height − Wall

1.52 m

$t_0 = 0s \qquad t_1 = 0.49s$

$x_0 = 0m \qquad x_1 = 8.0m$

$y_0 = 0m \qquad y_1 = 5.52\ m$

$v_{0x} = 16.4\ m/s \qquad v_{1x} = 16.4\ m/s$

$v_{0y} = 11.5\ m/s \qquad v_{1y} =$

$a_x = 0\ m/s^2 \qquad a_{1x} = 0\ m/s^2$

$a_y = -9.8\ m/s^2 \qquad a_y = -9.8\ m/s^2$

$x_1 = x_0 + v_{0x}\Delta t + \frac{1}{2}a_x(\Delta t)^2$

$8.0m = 0m + 16.4\ m/s\ \Delta t + \frac{1}{2}(0)\Delta t^2$

$8.0m = 16.4\ m/s\ \Delta t$

$\Delta t = \frac{8.0m}{16.4\ m/s}$ ✓

$\Delta t = 0.49$ ✓

$y_1 = y_0 + v_{0y}\Delta t + \frac{1}{2}a_y(\Delta t)^2$

$y_1 = 0m + 11.5\ m/s\,(0.49s) - 4.9\ m/s^2\,(0.49s)^2$

$y_1 = 5.635\ m - 0.12\ m$?? error. (-1)

$y_1 = 5.52\ m$ ~~should~~ gives 4.4m

$\boxed{1.52\ m}$

16

~~17~~ /18